Fuels, Engines, and Emissions

Understanding Particulate Formation Processes in High-Efficiency Clean Combustion (HECC)

Background

Compression-ignition (CI, or diesel) engines have long been known for their relatively high efficiency compared with spark-ignition (SI) engines. However, conventional approaches to diesel combustion have been plagued by a trade-off between nitrogen oxide (NO_x) and particulate matter (PM) emissions. A strategy that reduced one pollutant typically increased the other.

Recent theoretical and experimental studies describe the existence of combustion regimes which exhibit simultaneous low NO_x and PM emissions. Utilization of these regimes in production vehicles offers the opportunity to reduce the performance requirements for aftertreatment technologies and improve overall engine system efficiency.

This project focuses on improving the performance of high-efficiency clean combustion (HECC) and on expanding the engine operating space where this combustion strategy can be utilized. Data gathered during this project can help further the understanding of pollutant formation processes in near-production multi-cylinder engines. This understanding may lead to improved combustion models and engine designs.

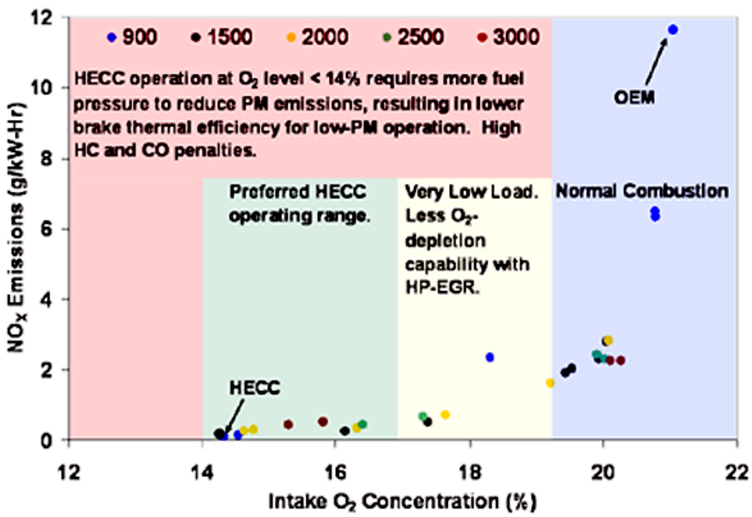

Figure 1. Engine-out NO_x emissons at various engine rpm levels and intake oxygen concentrations.

Technology

Studies performed by Oak Ridge National Laboratory (ORNL) have shown that low-temperature combustion strategies produce particulate that contains a large fraction of soluble organic compounds

Benefits

- Increased understanding of the PM-formation processes in production-like multi-cylinder engines that operate in HECC and related combustion modes.
- Improved models for emissions control technologies to foster better integration between emissions control technologies and combustion strategies.
- Development of strategies for improving engine system efficiency through thermodynamic analysis of HECC and related combustion modes.

and, in some cases, significant increases in semi-volatile species. Increasing the fuel volatility may allow broader use of HECC and related combustion modes.

Combustion strategies that use EGR to displace O_2 in the fresh charge can cause semi-volatile compounds to partition from the gas phase to the particulate phase. This results in potentially important PM measurement issues in HECC and related combustion modes. In addition, low-O_2 modes increased the levels of gas-phase soot-precursor species that continue to participate in soot-formation processes through recirculation in the EGR gases.

Status

ORNL is participating with fourteen other organizations in a Memorandum of Understanding (MOU) on Advanced Engine Combustion Research. In addition to dissemination of study findings through publications, such as through the Society of Automotive Engineers and the Combustion Institute, ORNL reports results to the group twice each year. ORNL also reports findings to industry stakeholders annually at both the Advanced Combustion and Emissions Program Merit Review and the Fuels Technology Program Merit Review.

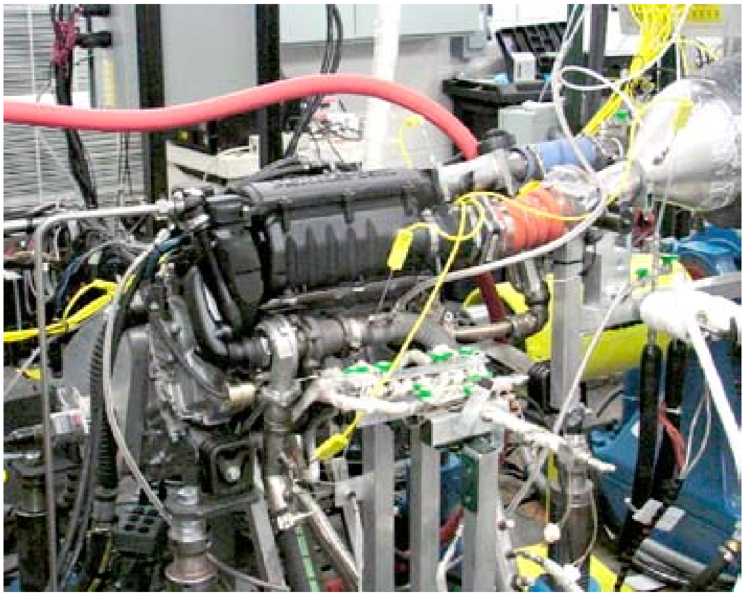

Figure 2. *Photograph of Mercedes 1.7 liter engine installed in ORNL engine research cell 4.*

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